



# Systems Analysis for Health Management

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## Objective

To gain insight into future requirements derived from probable adverse conditions and trends that might influence the Integrated Vehicle Health Management (IVHM) research portfolio and assessment/validations of the project.

## Analysis

Systems Analysis studies are completed through review/interpretation of statistical/prognostic data and literature to produce:

- IVHM Adverse Conditions
- State of the Art Assessment
- Causal Factor Analysis
- Assessment of Future Requirements
- Portfolio Assessment

## Solution

Systems Analysis studies will incorporate data from a variety of sources, including but not limited to:

- National Transportation Safety Board (NTSB)
- Aviation Safety Reporting System (ASRS)
- Aviation Safety Information and Analysis Sharing (ASIAS) System
- FAA Incident and Accident data
- Joint Strike Fighter Program
- Failure Modes and Effects Analyses (FMEA)
- Subject Matter Experts

## Results: IVHM Causal Factors & Adverse Conditions

Review statistical data and literature from academia, industry, and OGA to interpret/extract information about causal factors related to IVHM. Develop a list of adverse conditions against which IVHM technologies can be evaluated.

Refined Set of Adverse Conditions			
Adverse Event Type	Example Damage Condition	Severity and (Frequency)	Fatalities and Injuries
Incipient Fault: Hard to detect and differentiate due to extremely slow degradation in performance	1. Icing conditions in propulsion system	1. Accident (6)	1. Fatalities (3) Injuries (21)
	1. Fault of power electronics -Power drivers -Power supplies -Switching transistors -Electronics packaging -Electronic circuit boards	2. Accident (11) Incident (185)	2. Fatalities (1) Injuries (50)
	1. Turbine engine bearings -Fatigue spallation	3. Accident (4)	3. Fatalities (0) Injuries (3)
Slow Progression Fault: Very hard to detect, gradual degradation in performance	1. Fatigue cracks on metallic airframe structure	4. Accident (13) Incident (605)	4. Fatalities (12) Injuries (107)
	1. De-lamination in composites	5. Accident (2)	5. Fatalities (0) Injuries (6)
	6. Hydraulic failures - Ball-jam in EMA - Pneumatic system faults	6. Accident (18) Incident (657)	6. Fatalities (0) Injuries (58)
	7. A/C and pressurization faults	7. Accident (4) Incident (1247)	7. Fatalities (7) Injuries (40)
Intermittent Fault: Fault does not degrade but instead is a recurring hard fault that comes and goes, for example a signal conducted via a loose connector.	8. Oil/lubrication system failures	8. Incident (249)	8. Fatalities (0) Injuries (7)
	9. Wire chafing resulting in an electrical short due to an unexpected ground path	9. Accident (9)	9. Fatalities (0) Injuries (10)
Cascading Fault: Faults that may have a single root cause yet progress to create faults in other systems, subsystems, or components.	10. Power system faults resulting in wide-spread systemic issues -Electrical distribution problems	10. Accident (10) Incident (484)	10. Fatalities (233) Injuries (28)
	11. Aileron, rudder, or control surface (elevator) faults	11. Accident (22) Incident (996)	11. Fatalities (285) Injuries (9)
	12. Instrumentation, communication, and navigation	12. Accident (5) Incident (3208)	12. Fatalities (4) Injuries (21)
Fast Progression Fault: Limited precursor signature but rapid degradation	13. Fuel system faults	13. Accident (20) Incident (278)	13. Fatalities (17) Injuries (49)
	14. Engine stall/faults in turbomachinery	14. Accident (52) Incident (2424)	14. Fatalities (227) Injuries (407)
	15. Landing gear faults -Gear extension/retraction	15. Accident (97) Incident (1238)	15. Fatalities (5) Injuries (123)
	16. Brake/anti-skid system faults	16. Accident (23) Incident (286)	16. Fatalities (70) Injuries (0)
	17. Software Faults	17. Incident (408)	17. Fatalities (n/a) Injuries (n/a)
18. Lightning and radiation related avionics faults	18. Accident (1)	18. Fatalities (0) Injuries (0)	

System	System/Component Failure/Malfunction Accident Grouped by System Affected and by Operation Category			
	Part 121	Scheduled Part 135	Non-Scheduled Part 135	Part 121 & 135 Combined
Electrical	8 (7%)	1 (3%)	12 (5%)	21 (6%)
Engine	36 (33%)	12 (36%)	111 (49%)	159 (43%)
Flight Control	10 (9%)	3 (9%)	9 (4%)	22 (6%)
Fuel	4 (4%)	3 (9%)	13 (6%)	20 (5%)
Hydraulic	9 (8%)	2 (6%)	7 (3%)	18 (5%)
Instrumentation/Communication/Navigation	5 (5%)	0 (0%)	0 (0%)	5 (1%)
Landing Gear	23 (21%)	10 (30%)	64 (28%)	97 (26%)
Structure	5 (5%)	1 (3%)	7 (3%)	13 (4%)
Other	8 (7%)	1 (3%)	4 (2%)	13 (4%)
Unknown	1 (1%)	0 (0%)	1 (0%)	2 (1%)
<b>Total Accidents</b>	<b>109</b>	<b>33</b>	<b>228</b>	<b>370</b>

System Group	Accident Characteristics	System/Component Failure/Malfunction Accident Characteristics by System Group and by Operation Category		
		Part 121	Scheduled Part 135	Non-Scheduled Part 135
Engine or Fuel System	Total Accidents	40	15	124
	Fatal Accidents	4 (10%)	3 (20%)	37 (30%)
Flight Control or Structure	Total Accidents	151	33	92
	Fatal Accidents	151	33	92
Landing Gear or Hydraulic	Total Accidents	15	4	16
	Fatal Accidents	7 (47%)	1 (25%)	4 (25%)
Instrument/Communication/Navigation, Electrical, Other, Unknown	Total Accidents	279	14	4
	Fatal Accidents	279	14	4
Total	Total Accidents	32	12	71
	Fatal Accidents	0 (0%)	1 (8%)	0 (0%)
Total	Total Accidents	0	5	0
	Fatal Accidents	0	5	0
Total	Total Accidents	22	2	17
	Fatal Accidents	5 (23%)	0	6 (35%)
Total	Total Accidents	347	0	13
	Fatal Accidents	347	0	13

## Results: Future Requirements for IVHM Technology

Statistical data and literature from academia, industry, and OGA were reviewed to interpret/extract information to establish future requirements of IVHM technologies. 25 IVHM technology need areas were identified and :

- Organized into the areas of detection, diagnosis, prognosis, mitigations and integrity assurance
- Mapped to the Adverse Conditions Table
- Prioritized using three different methods

## Results: Assessment of the State of the Art

State of the art assessment was completed for IVHM related technology as applicable to the adverse conditions.

- Literature from over 100 sources (industry, academia, and other government agencies) was searched (2004-2008), including conference proceedings, journal articles and technical reports
- More research is needed in the areas of system level perspective & integration, mitigation, and basic physical phenomenon that cause faulty behavior in flight systems